



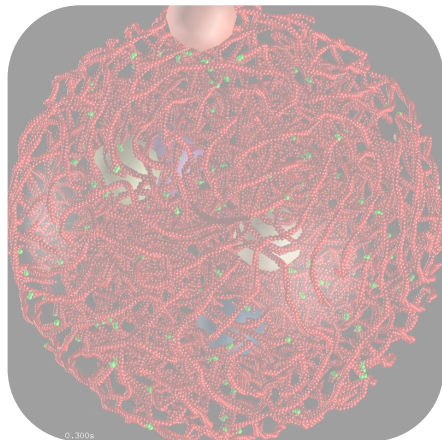
Renewing Active Matter: multi-cellular assemblies and sub-cellular cytoskeleton networks

Patrick Zimmer and Yoav G. Pollack
SWZ workshop 15.08.2024

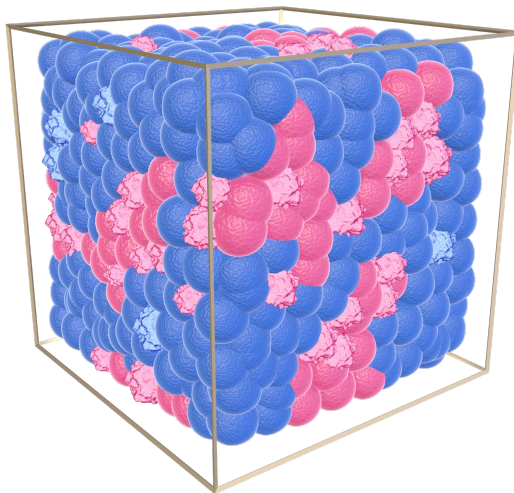


Renewing Active Matter (RAM)

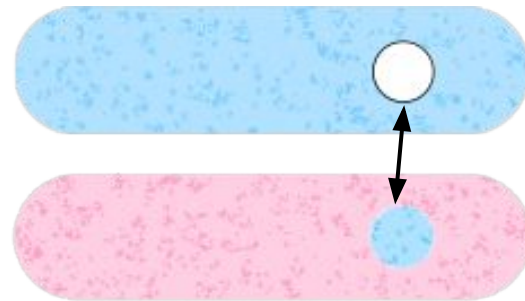
Cytoskeleton



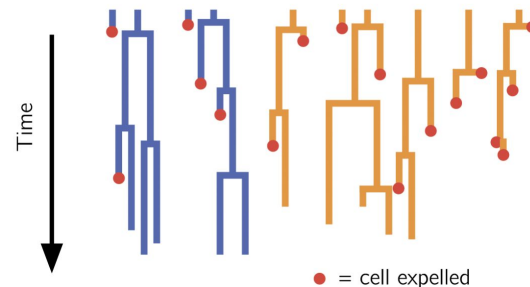
Tissues



Simulate competition,
transplants, regeneration, etc.



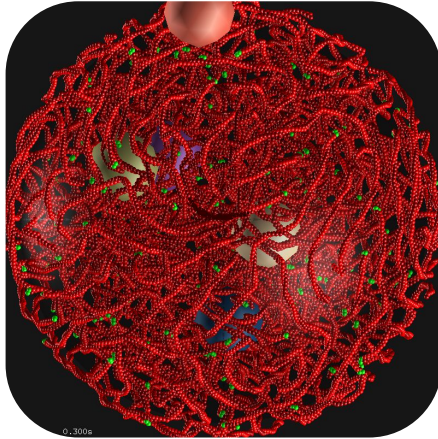
Continuous injection of DoF



Levien, E., Min, J., Kondev, J., & Amir, A. (2021). Reports on Progress in Physics, 84(11), 116601.

Cytoskeleton as RAM

Simulation

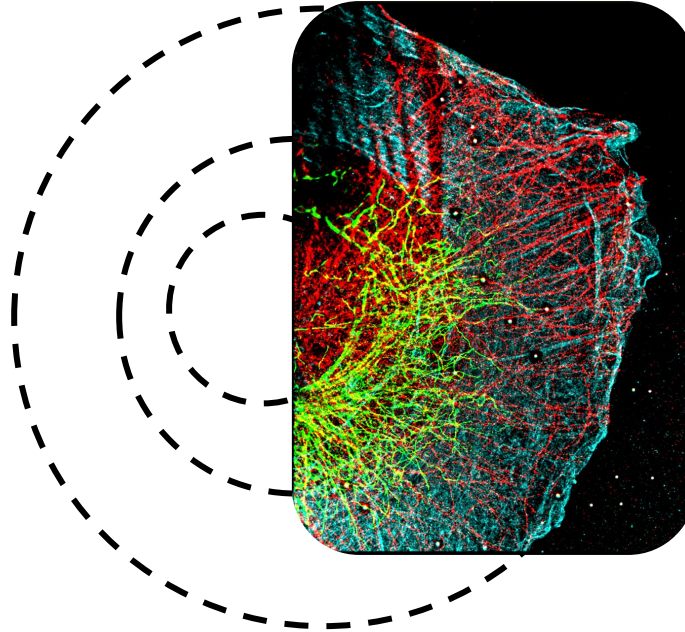


Cytosim



Cytocalc

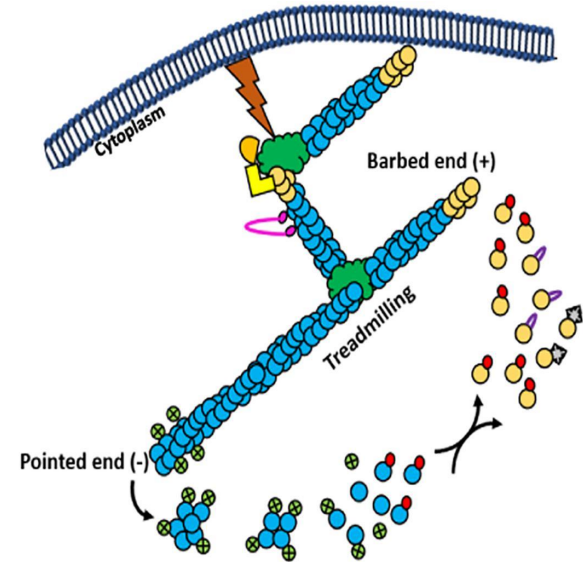
Super-resolution image



Credit: Roman Tsukanov,
Samrat Basak. Enderlein lab



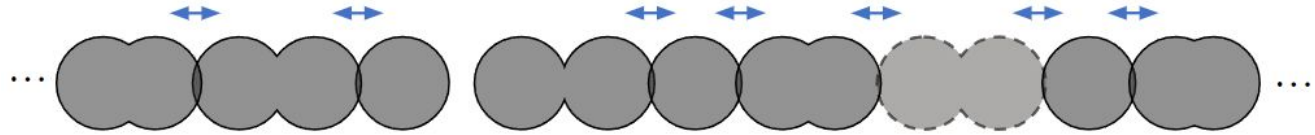
Renewal via polymerization, severing, etc.



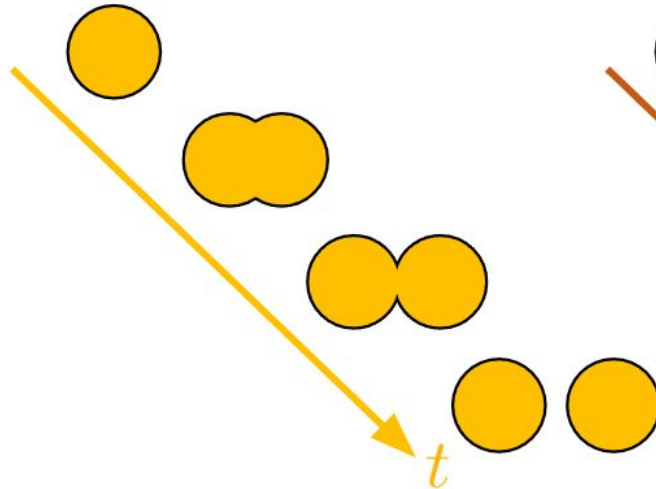
Actin filament growth, shrinking and treadmilling.
Gupta, Bindu, Rani. *Frontiers in Cell and
Developmental Biology* 8 (2020) 587685

Minimal Cell Model

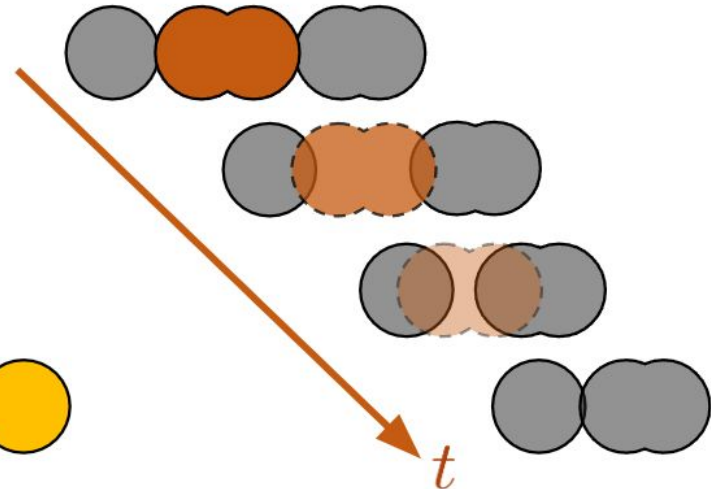
(1) steric interactions



(2) growth & division

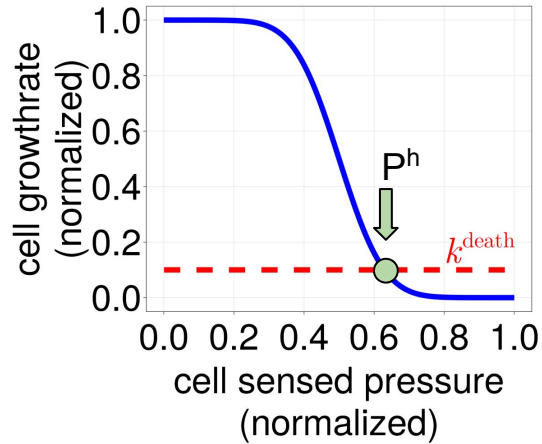


(3) degradation after death

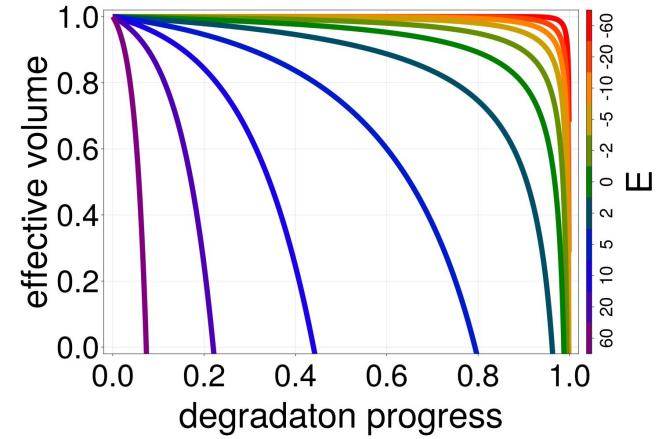


Minimal Cell Model

(4) pressure regulated growth

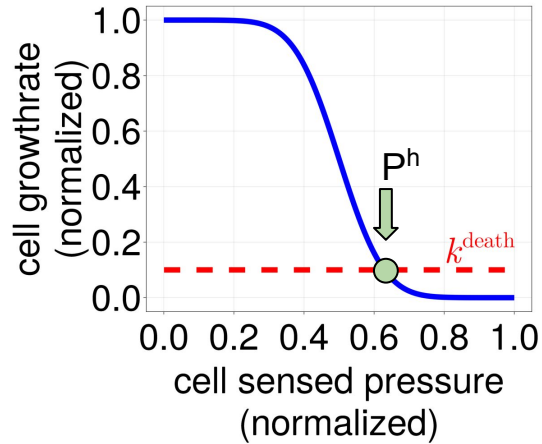


(5) modulated degradation E

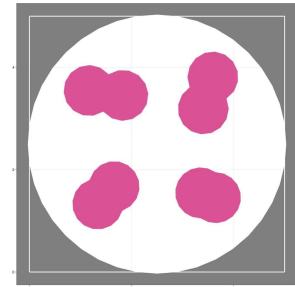
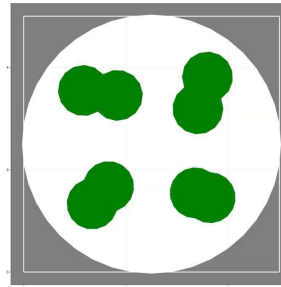
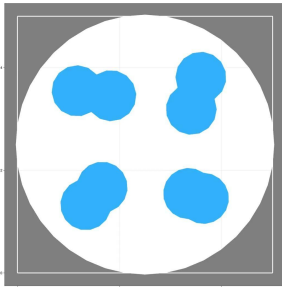
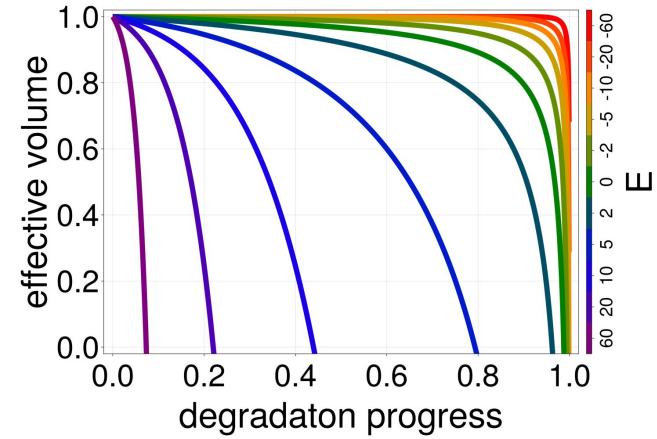


Minimal Cell Model

(4) pressure regulated growth



(5) modulated degradation E



Agent Based Modelling

Interacting Particle Simulations

using **InPartS.jl**



inparts.org



J. Isensee, L. Hupe, R. [Golestanian](#), P. [Bittihn](#),
J. R. Soc. Interface **19**, 20220512 (2022)

T. Sunkel, L. Hupe, P. [Bittihn](#) , [arXiv](#) 2403.11002 (2024)

Philip Bittihn



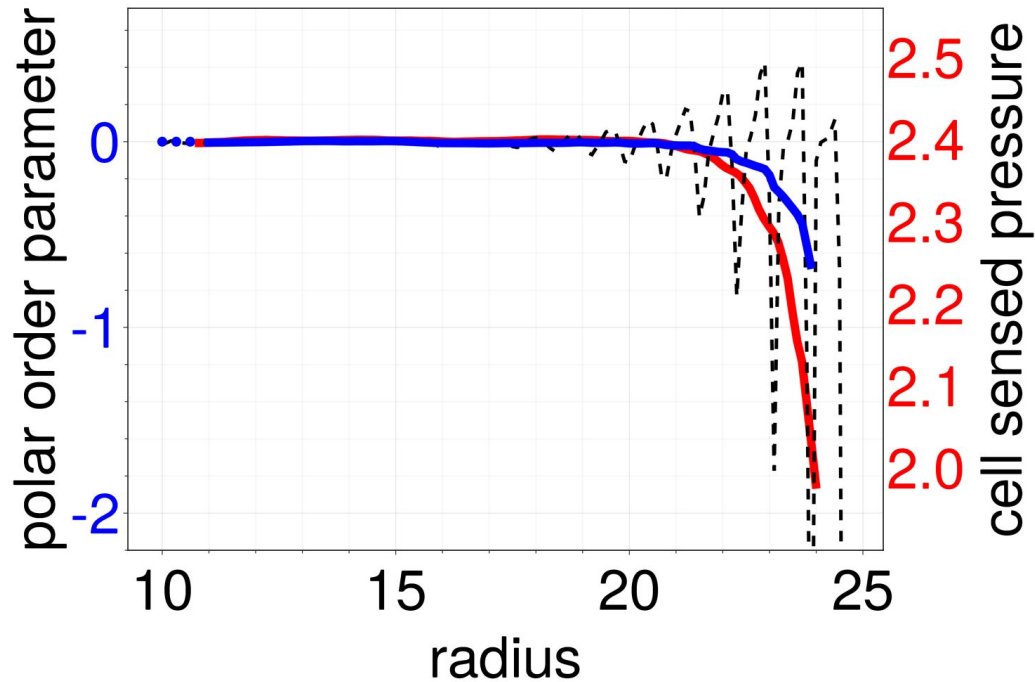
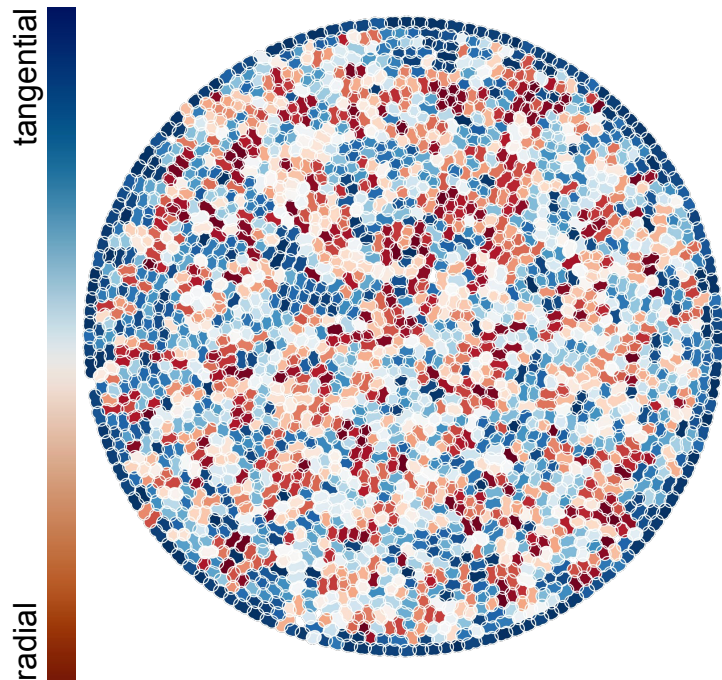
Lukas Hupe



Jonas Isensee

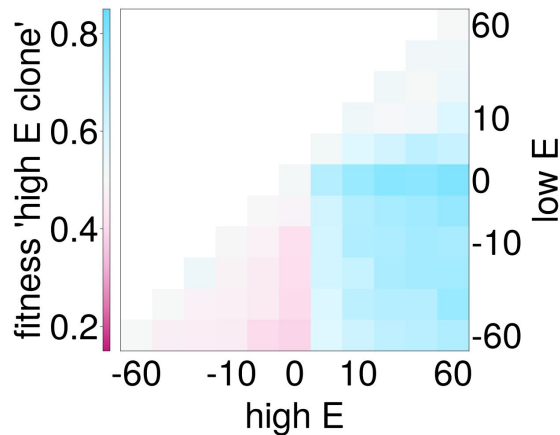


Spatial Heterogeneity



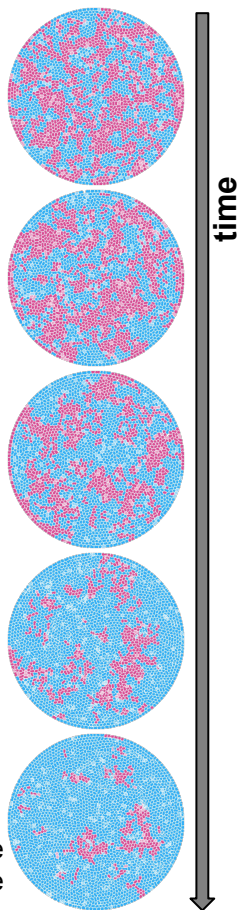
Non-Adversarial Competition

Fitness in the bulk

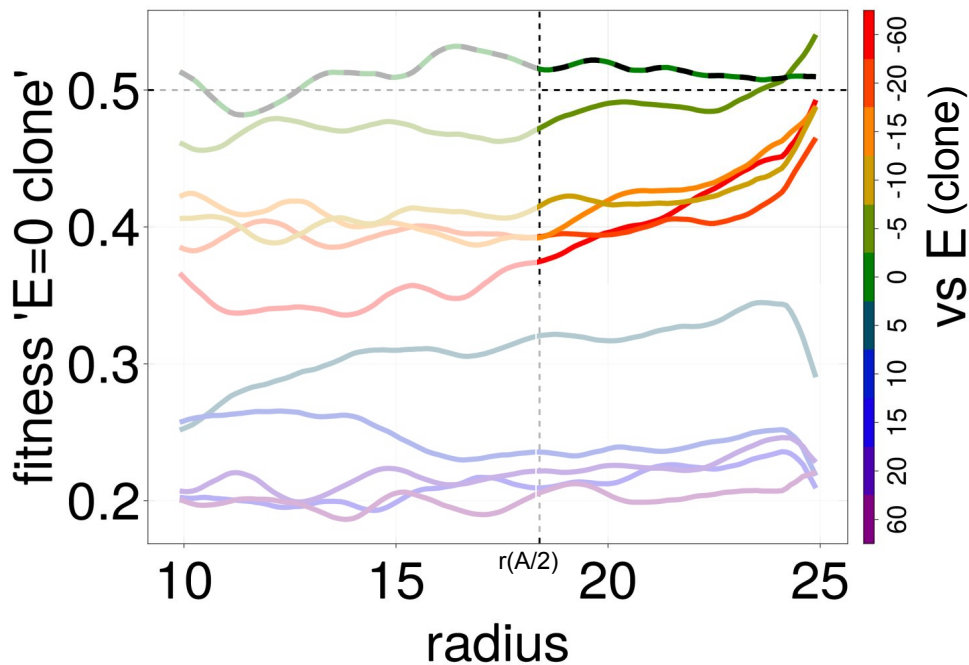


$$F_{[H,L]} = \frac{N_{[H,L]}^t}{N^t}$$

- lower E clone
- higher E clone



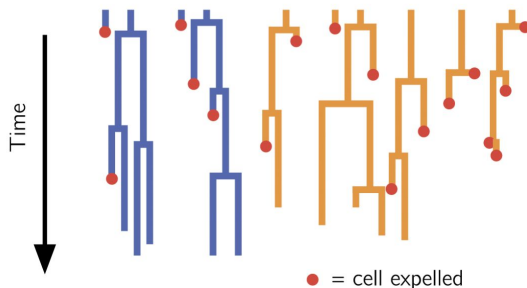
Spatially varying fitness



Challenges with RAM

Particle trajectories

MSD

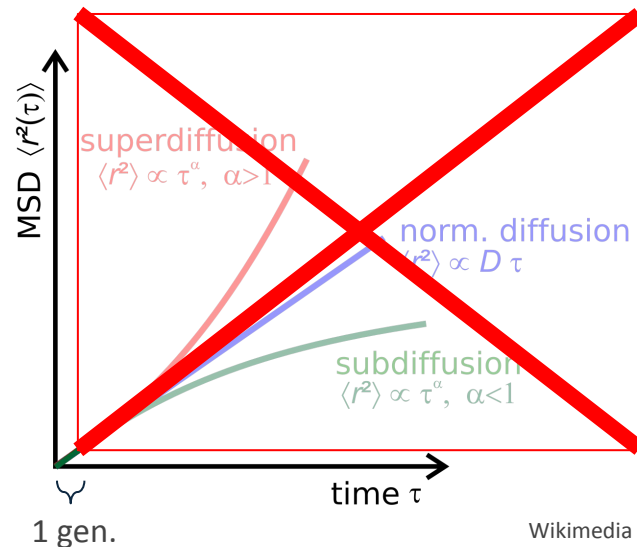


New cells at division

→ Tracer particles?

→ Tracking over generations?

What about ending trajectories?

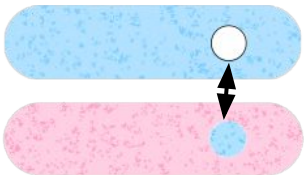


3D - Confinement + Adhesion

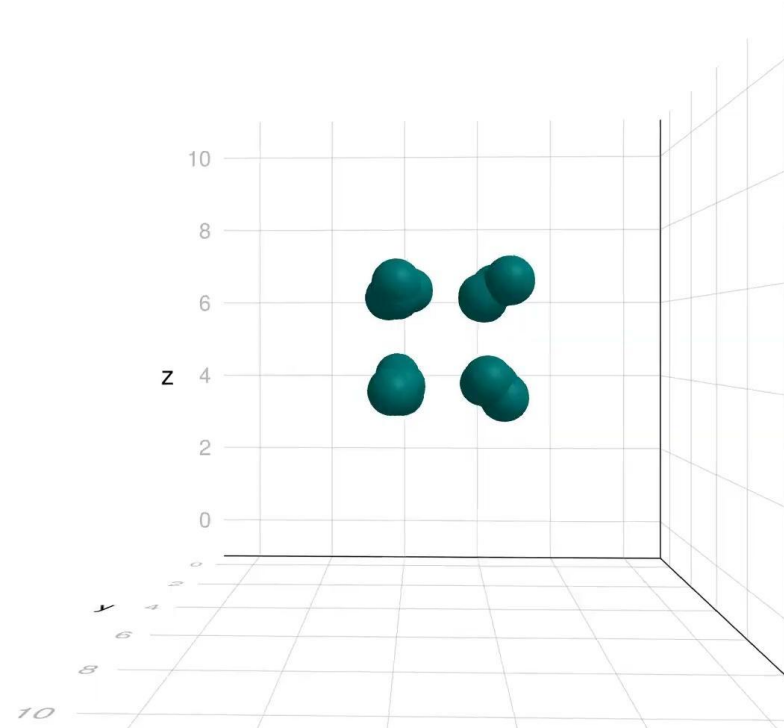
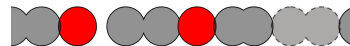
decoupling of:

- layer structure
- polar orientation
- pressure heterogeneity
- spatial fitness

Competition in
tissue transplants



Effective
forces



Credit: Torben Sunkel MPI-DS